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PHYSICS

ON A POSSIBLE INTERPRETATION OF THE NEW SYSTEM OF TiO BANDS IN THE INFRA-RED

By P. P. DOBRONRAVIN

(Communicated by D. S. Roždestvenskij, Member of the Academy, 1. X. 1937)

As is known([1],[2],[3]), the spectrum of TiO molecules consists of three systems of bands: 1) the green-blue system (α), corresponding to the transition $^3\Pi—^3\Pi$ for which the frequency formula is

$$\nu_{(cm^{-1})} = \left.\begin{matrix}19434.48\\432.58\\423.75\end{matrix}\right\} + \left[\ 837.86\left(v' + \tfrac{1}{2}\right) - 4.546\left(v' + \tfrac{1}{2}\right)^2\right] - \left[1008.12\left(v'' + \tfrac{1}{2}\right) - 4.519\left(v'' + \tfrac{1}{2}\right)^2\right],$$

2) the red-infra-red system (γ), corresponding to the transition $^3\Sigma—^3\Pi$ and represented by the formula:

$$\nu = \left.\begin{matrix}14242.6\\175.9\\101.3\end{matrix}\right\} + \left[\ 866.24\left(v' + \tfrac{1}{2}\right) - 3.82\left(v' + \tfrac{1}{2}\right)^2\right] - \left[1009.07\left(v'' + \tfrac{1}{2}\right) - 4.75\left(v'' + \tfrac{1}{2}\right)^2\right],$$

3) the yellow-orange system (β), whose detailed analysis has not yet been done. The lower level $^3\Pi$, common for the systems α and γ, is considered to be the normal one for the TiO molecule.

Till now, the region up to 8000 Å has been investigated.

Recently Wurm and Meister ([4]) reported the wave-lengths of the heads of TiO bands found in the region 8000—12000 Å. Part of these bands belongs to the well-known system γ, the others possibly form a new system.

The authors do not give an analysis of the structure of this system; they only point out that the bands in question are probably singlets. The analysis of this observational material performed by me justifies the conclusion that a part of the new bands belongs to a new system having the same lower level as the system α and γ.

In all, 36 wave-lengths of the heads of non-identified bands have been reported. It is probable that three of them belong to the system γ, five have a shading towards the violet, unlike what is observed in the known bands.

Nine heads may be arranged in a scheme in which the differences between the vibrational levels of the lower state are near to the same differences for

Table 1

v' \ v''	0	1	2	3	4	5	6	7
a	11284.2	10280.1						
		1004.1						
0*b*		906.5						
c								
a		11186.6	10187.1					
			999.5					
1*b*		905.6	10123.0					
c			902.0					
a		12092.2	11089.1	10099.5				
			1003.1	989.6				
2*b*			891.8					
c				9955.0				
a			11980.9		10011.6			
			(990 + 979.3)					
3*b*								
c			11843.7		9874.6		8962.1	
a								
					10830.9?	9853.7?	8896.0	
4*b*					977.2	957.7		
c								
a							Q?	
5*b*								
c								
a						11651.7		
6*b*								
c								
a								10591.3?
7*b*								
c								

the normal level ($^3\Pi$) of the TiO molecule (Table 1). Further, we have found three bands, the frequencies of whose heads are less than those of the bands arranged in the scheme by a quant ty very near to that corresponding to the full separation of the normal triplet level of TiO, and one band with a difference corresponding to the difference between the two lower sub-levels of the normal state. The arrangement of the bands in the scheme in question corresponds to Frank-Condon's «narrow parabola» and is very similar to that observed in the system γ. Part of the bands have Q-heads, whose frequencies are less than those of R-heads by 13 cm^{-1}.

On the basis of Table 1, it may be assumed that the system of bands under consideration has a triplet structure, but for some unknown reason, the strongest of them correspond to the transition to the lower sub-level of the normal state (a), less strong ones are those corresponding to the transition to the upper sub-level (c), while the weakest are those corresponding to the transition to the middle sub-level (b). The least squares solution leads to the following formula for the new system:

$$\nu = \left.\begin{matrix} 11334.1 \\ 269.9 \\ 194.3 \end{matrix}\right\} + \left[\, 924.70\left(v' + \tfrac{1}{2}\right) - 5.46\left(v' + \tfrac{1}{2}\right)^2\right] - \left[1021.07\left(v'' + \tfrac{1}{2}\right) - 5.03\left(v'' + \tfrac{1}{2}\right)^2\right].$$

By this formula we are able to represent approximately 18 heads (plus 4 Q-heads) (Table 2; all these heads are included also in Table 1). However, some coincidences are doubtful. The $O—C$ differences («observation minus computation») are rather great, but it is hardly to be supposed that the result obtained is due to chance.

The expression for the vibrational energy of the lower level does not completely coincide with that for the normal level but is so near to it, that the existence of a new level approaching the normal one and having the same triplet separation is unlikely. The new system of bands should correspond to the transition $^3\Sigma—^3\Pi$ (in emission), unless a combination between the normal triplet level and a level of another, singlet, system were considered probable; however, such a combination is but little probable.

One is puzzled by the absence of the band (1, 0), which, from theoretically considerations, was expected to be rather intense; this band is not overlapped by those belonging to the system γ. It is also difficult to explain the great value of $O—C$ for the band (0, 1) *Ra*, which, nevertheless, seems to have been correctly identified.

Wurm and Meister do not state the intensities of the bands, but it is seen, from the photographs reproduced in their paper, that the strongest of them are the bands 8859.5 (0,0), 8936.8 (1,1) and 9015.4 (2,2), as was to be expected from the distribution of the bands according to vibrational levels shown in Table 1.

It is interesting to compare the schemes of the levels of TiO and ZrO molecules. The Ti atom has, outside the inner closed shells, two $3d$ electrons and two $4s$, whereas Zr has two $4d$ electrons and two $5s$. For this reason, it may be expected that, when these atoms are combined with the oxygen atom, a similar scheme of the energy levels will be obtained. The scheme of the levels of a TiO molecule is represented in Fig. 1, where the new level suggested by me is shown by a dotted line, while the new band-system is denoted by δ. The scheme of the levels of a ZrO molecule([5]) is shown in Fig. 2. The arrangement of the levels of these molecules proves to be similar, and this may be considered as corroborating the interpretation of the new infrared system suggested above.

λ (Wurm and Meister)	$\nu_{obs.}$	$\nu_{calc.}$	$O-C$	φ', φ'' (δ)	Remarks
	cm.$^{-1}$ (vacuum)				
8267.5	12092.2	12091.4	+0.8	(2,1) *Ra*	—
8344.3	11980.9	11982.4	−1.5	(3,2) *Ra*	8343.2 γ(1,3) *Qb* **
8441.0	11843.7	11842.6	+1.1	(3,2) *Rc*	—
8450.5	11830.4	11829.6	—	(3,2) *Qc*	—
8513.5	11742.8	—	—	—	8512.6 γ(3,5) *Qb* *
8558.5	11681.1	—	—	—	8558.6 } γ(3,5) { *Rc* **
8569.0	11666.8	—	—	—	8567.0 } { *Qc* *
8580.1***	11651.7	11650.2	+1.5	(6,5) *Ra*	—
8623.9***	11579.1	—	—	—	—
8774.5	11393.5	—	—	—	Shading towards the violet
8819.3	11335.7	—	—	—	» » » »
8859.5	11284.2	11285.8	−1.6	(0,0) *Ra*	—
8869.5	11271.5	11272.8	—	(0,0) *Qa*	—
8936.8	11186.6	11188.6	−2.0	(1,1) *Ra*	8933.6 γ(0,3) *Qa* *
8947.0	11173.9	11175.6	—	(1,1) *Qa*	—
9015.4	11089.1	11090.4	−1.3	(2,2) *Ra*	9015.9 γ(1,4) *Ra* *
9230.3	10830.9	10827.5	+3.4	(4.4) *Rb*?	—
9252.5	10804.9	—	—	—	9254.5 γ(3,6) *Rb* *
9284.0	10768.3	—	—	—	—
9439.1	10591.3	10587.1	+4.2	(7,7) *Ra*?	9439.7 γ(5,8) *Rb* *
9486.0	10539.0	—	—	—	Shading towards the violet
9533.9	10486.0	—	—	—	» » » »
9652.4	10357.3	—	—	—	» » » »
9682.3	10325.3	—	—	—	—
9724.9	10280.1	10274.8	+5.3	(0,1) *Ra*	—
9813.6	10187.1	10187.6	−0.5	(1,2) *Ra*	—
9875.8	10123.0	10123.4	−0.4	(1,2) *Rb*	—
9898.8	10099.5	10099.6	−0.1	(2,3) *Ra*	—
9985.7	10011.6	10010.7	+0.9	(3,4) *Ra*	—
10024.9	9972.4	—	—	—	10022.1 γ(1,5) *Qc* *
10042.5	9955.0	9959.8	−4.8	(2,3) *Rc*?	—
10124.2	9874.6	9870.9	+3.7	(3,4) *Rc*?	—
10145.7	9853.7	9856.8	−3.1	(4,5) *Rb*?	—
10177.5	9822.9	9817.4	—	(5,6) *Qa*?	—
11030.0	9063.7	—	—	—	—
11091.0	9013.9	—	—	—	11087.5 γ (2,7) *Rb* *
11155.0	8962.1	8960.2	+1.9	(4,6) *Ra*	—
11238.0	8895.9	8896.0	−0.1	(4,6) *Rb*	—

* λ were computed according to Lowater's formula (l. c.).

** According to Wurm and Meister (l. c.), the wave-length of γ (3,5) *Rc* is 8558.6, which practically coincides with the unknown band 8558.5. However, on the reproduction of the spectrum (Fig. 1 in their paper), the indices of the heads 8558.5 and 8569.0 are displaced towards the longer wave-lengths by 10 Å, which seems to be erroneous. It is hardly possible to separate two heads with a difference of wave-lengths of 0.1 Å at the dispersion used (about 6 Å per mm).

*** According to Merill's mesurements in the spectrum of *R* Hydrae. [6]

The interpretation given here is not definitive and should be regarded as a «first approximation» to be improved by further investigations. It is particularly important to ascertain the cause of the difference between the value of the vibrational quantum of the lower level as computed on the

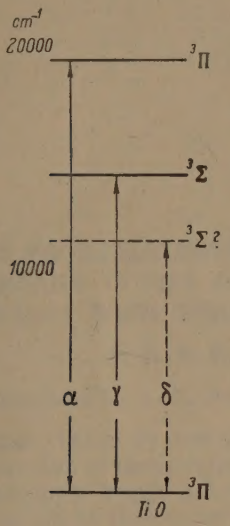

Fig. 1.

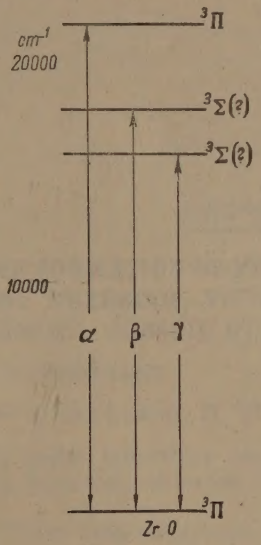

Fig. 2.

basis of the analysis of the new system and its value computed on the basis of the analysis of the systems known earlier. This difference may cause some doubts as to the correctness of the identification.

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GEOPHYSICS

ON THE PROBABLE MECHANISM OF THE FORMATION OF PERIODIC ICE STREAKS IN THE COURSE OF SOIL FREEZING, VIEWED IN CONNECTION WITH PERMANENTLY FROZEN SUBSOIL QUESTION

By F. M. ŠEMIAKIN and P. F. MIKHALEV

(Communicated by A. D. Arkhangelskij, Member of the Academy, 27. X. 1937)

Stephen Taber (1) has studied in detail, under laboratory conditions, the mechanism of the so-called «frost heaving», frequently observed in regions of permanently frozen subsoil.

He has shown that under those conditions water does not freeze uniformly throughout the thickness of the ground.

Ice forms all kinds of streaks, such as horizontal layers, spiral lenses, nuclear structures, etc. The most frequent is the formation of periodic horizontal ice layers, ice closely resembling the periodic depositions of sediment known as Liesegang's rings.

No satisfactory explanation has so far been suggested for the periodic formation of ice streaks in the course of soil freezing, in the direction from the surface downwards.

Taber (2) writes, for instance: «Therefore, it is not possible to give a complete explanation at the present time, and only a tentative hypothesis is offered here».

In this paper we shall endeavour to explain the periodic distribution of ice in the process of ground freezing on the base of the analogy between the equations of heat conduction and diffusion.

The equivalency of concentration and temperature may also be inferred from the principles of chemico-physical analysis as developed by Acad. N. S. Kurnakov (3).

Moreover, the movement of water in the ground is known to be analogous to the diffusion of a solution and to the movement of heat in a non-uniformly heated body.

It is of interest to note that the process of formation of periodic ice streaks is absolutely analogous to the formation of Liesegang's rings.

In Taber's experiments, the cylindrical layer of clay or any other soil is analogous to a cylindrical layer of gelatine, water, or any other medium in the experiments with Liesegang's rings, the inner component being the water uniformly distributed in the soil. The outer component, in this case, is cooling, which gradually extends from the surface down into the soil.

This analogy becomes still more marked if it is remembered that chemical reactions are not essential to periodic deposition as proved by numerous

Table 1

Nos of experiments	I					
Nos of ice layers	1	2	3	4	5	6
Spacing in cm	0.35	0.42	0.57	0.70	0.90	
K		1.2	1.3	1.2	1.3	

Nos of experiments	II				
Nos of ice layers	1	2	3	4	5
Spacing in cm	0.10	0.11	0.12	0.15	
K		1.1	1.1	1.3	

Nos of experiments	III						
Nos of ice layers	1	2	3	4	5	6	7
Spacing in cm	0.20	0.25	0.28	0.25	0.35	0.40	
K		1.3	1.1	0.9	1.4	1.1	

Nos of experiments	IV						
Nos of ice layers	1	2	3	4	5	6	7
Spacing in cm	0.20	0.25	0.30	0.42	0.45	0.50	
K		1.3	1.2	1.4	1.1	1.1	

Nos of experiments	V				
Nos of ice layers	1	2	3	4	5
Spacing in cm	0.35	0.50	0.65	0.78	
K		1.4	1.3	1.2	

Nos of experiments	VI					
Nos of ice layers	1	2	3	4	5	6
Spacing in cm	1.0	1.3	1.4	1.6	1.7	
K		1.3	1.1	1.1	1.1	

Nos of experiments	VII					
Nos of ice layers	1	2	3	4	5	6
Spacing in cm	0.20	0.20	0.25	0.25	0.30	
K		1.0	1.3	1.0	1.2	

experiments of Hedges and other authors (periodic coagulation, periodic salting out, etc.).

All this proves that what is essential is the process of diffusion of the outer component, or, in the case under consideration, the process of the gradual diffusion of the soil by cooling.

If, starting from the analogy between the equations of diffusion and heat conduction, we apply to this case the relation well confirmed experimentally on Liesagang's rings and obtained by K. Jablczynski ([4]), we may derive a law that would govern the distribution of ice streaks in Taber's experiments.

A relationship analogous to the one derived by Jablczynski would in this case have the form:

$$\frac{h_n - h_{n-1}}{h_{n-1} - h_{n-2}} = \text{const}, \qquad (1)$$

where h_n is the distance to the nth layer; h_{n-1}, the distance to the $(n-1)$th layer; h_{n-2}, the distance to the $(n-2)$th layer.

This relation is actually confirmed by measuring the spacings between the individual ice streaks in the soil pillars of Taber's experiments. Such measurements were made by the writers on the photographs appearing in Taber's paper (Table 1).

Table 2 shows a comparison of the mean constants of all the experiments.

Table 2

Nos of experiments	I	II	III	IV	V	VI	VII
Mean K	1.25	1.17	1.16	1.22	1.30	1.15	1.13

The mean of all the experiments is 1. 2*.

Taber's experimental data thus actually confirm the formula derived by the authors.

The work is being continued.

Conclusions

1. From the analogy between the differential equations of diffusion and heat conduction, there has been derived a law governing the spacings between ice streaks in «frost heaving».

2. This regularity is confirmed by S. Taber's experimental data.

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* This value practically coincides with the value of the constant for Liesegang's rings.

Comptes Rendus (Doklady) de l'Académie des Sciences de l'URSS
1937. Volume XVII, № 8

BIOPHYSICS

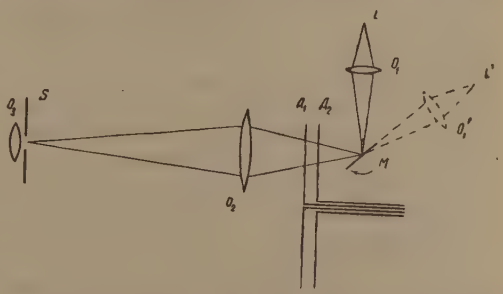
A DEVICE FOR THE INVESTIGATION OF THE SENSITIVITY OF THE EYE TO ULTRA-SHORT ILLUMINATION

By B. DERIAGIN

(Communicated by P. P. Lazarev, Member of the Academy, 31. VII. 1937)

The dependence of the boundary light intensity on the duration of illumination of the eye t, for t below 10^{-4} sec, remains to be a question requiring elucidation.

As the study of the above dependence is important for the question of summation of the action of photones in the retina, in connection with the refraction pause phenomena, which question is now being studied by the author in the Biophysical Department of the Union Institute of Experimental Medicine, the author undertook the construction of a device for obtaining single light stimuli with duration from 10^{-7} sec. to 10^{-3} sec.



The device is schematically shown in the figure (view from above).

The linear source of light L (the vertical slit of the illuminating object) is projected by the lens O_1 upon the mirror M. The lens O_2 throws the image of the source of light upon the slit S, the width of which may be adjusted by means of a micrometric screw. The spy glass (represented schematically by the lens O_3) is focussed against the mirror M in such a way that in the absence of the lens O_2 the rays from the source of light L are collected in the retina of the observer's eye giving its distinct image.

In the presence of the lens O_2 there is, consequently, a certain illuminated space which is not displaced when the mirror M rotates. At such a rotation, however, the image of the source of light thrown by the lens O_2 moves across the slit S; thus, the width of the slit d, its distance from the mirror l and the angular speed of rotation of the latter ω determine the duration of the illumination of the eye t, which is, apparently, equal to:

$$t = \frac{d}{2l\omega} = \frac{d}{4\pi ln}, \qquad (1)$$

where n is the number of revolutions per second.

If $d=1$ mm, $l=2\,500$ mm and $n=200$, $t\approx 1.5\cdot 10^{-7}$ sec. By increasing d to 10 mm and decreasing the number of revolutions to $^1/_3$, t may be increased to 10^{-3} sec.

In order to be able to study the action of single flashes or, what is practically the same, of flashes with intervals of 3 sec., 2 rotating discs D_1 and D_2 with sector cuts were placed between the mirror and lens O_2. In the figure the rotation of these discs is shown as taken out aside from the pencil of rays intersected by them, but actually the axes were under the latter so that at the moment of passing the light the cuts of the discs were parallel to the slit of the illuminating object L.

The destination of the discs is to reduce the number of flashes, observed at the rapid rotation of the mirror up to 20 revs per min. At a low speed of rotation of the mirror disc D_1 with a narrow cut, making 20 revs per min. would be sufficient for this purpose. At high speeds of rotation of the mirror this disc would pass several flashes in succession as the sector cut in the disc can not be narrowed to a smaller width than that of the pencil of rays passing through it.

To select the series of flashes which are passed through the first disc and are rapidly following one after another (with a great number of revolutions of the mirror), is the task of the disc D_2 which makes 10 revs per sec. The width of the cut in the disc is adjusted according to the number of revolutions of the mirror.

The pencil of light is, apparently, passing through when the cuts of the two discs happen to be simultaneously on its way.

The fundamental technical difficulty in the construction of the device was that the rotation of both discs and that of the mirror have to be made to agree with each other at different numbers of revolutions of the mirror, so that the passing of the pencil of light through the discs could take place permanenly at such positions of the discs that would enable an image of the source of light to pass through the immovable slit S just during the time after the way through the discs D_1 and D_2 becomes «free» and before it is «closed» again.

To ensure this condition the discs were connected by pinions with the shaft of the gear-box by which the mirror was put into motion, the shaft being driven by a synchronous motor.

In order to study the summation of the action of two flashes following each other after short intervals of time it suffices to replace the single slit S by two slits the distance between which may be adjusted.

In order to obtain a flash more than twice, several sources of light L, L' with corresponding lenses were used. All these sources of light with the lenses were able to turn around the axis of the mirror being fastened on horizontal rods with hinges; by changing the angles between the different rods it was possible to adjust the intervals between the light stimuli.

The device was constructed in the workshops of the Union Institute of Experimental Medicine and Biology (VIEM) under the supervision of Engineer A. F. Šesterenko.

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PHYSICAL CHEMISTRY

CYCLOCHRONOGRAMS OF SALT LAKES. ELTON LAKE (1932—1936)

By N. S. KURNAKOV, Member of the Academy, I. B. FEIGELSON and A. G. BERGMAN

The complex physico-chemical processes taking place in salt lakes can be essily deciphered with the aid of poly-dimensional geometry methods.

In the intricate complex of natural salt equilibria, we have, on the one hand, the independent chemical factors, i. e. the salt components, and, on the other, a number of physical factors: time, temperature, etc.

One of the achievements of topology as applied to physico-chemical analysis is the equalization of components and factors in complex physico-chemical diagrams. By simplifying the composition of salt lakes and by selecting the most essential components only, it becomes possible, for an overwhelming majority of them, to reduce the number of independent components to three: The reciprocal system $2\,NaCl+MgSO_4 \rightleftarrows Na_2SO_4+MgCl_2$ composed of four reciprocal salts has, accroding to Gibbs's phase rule, three independent components, since the amount of the salt depends on the quantity of the first three salts. Water is the fourth independent component. If we add to this temperature and time, we in all obtain six topological «components». The state diagram of such a system is represented by a figure of the fifth dimension. In reality this figure may be represented as a complex of projections. Scoute (1) was one of the first to suggest the tetrad method to represent on a plane the elements of the pentatope, the simplest figure of the fourth dimension (Fig. 1). More complex diagrams can also be represented by a combination of projections, more particularly, the points of the hexatope may be represented by hexads of points.

A continuous five year study of the annual cycle of Lake Elton, the largest of Europe's salt lakes, carried out by I. B. Feigelson and N. A. Shlesinger, of the Central Salt Station, Saratov, assisted by A. P. Larina, A. A. Koževnikova and E. V. Petukhova, has yielded a remarkable wealth of material (2). Samples of salt solution and bottom salts were taken every ten day, the meteorological observations being made three times a day. There are in all as many as 300 lake analyses, as well as about 150 analyses of the experimental basin, ranging over a period of three years.

All these data were subjected to a detailed physico-chemical analysis on the basis of 0°, 25°, 35°, and 45° diagrams studied by N. S. Kurnakov, S. F. Zemčužnyj (3), A. P. Opykhtina (4), N. K. Voskresenskaja (5), A. G. Bergman, N. S. Dombrovskaja and G. M. Unžakov, and also on the basis of a complete polytherm of the reciprocal system of sodium and magnesium

chlorides and sulphates, studied, in the interval between complete freezing, —36° and +25°, at the State Institute of Applied Chemistry ([6]) by A. G. Bergman, A. P. Palkin, E. N. Varasova, V. S. Jegorov, A. I. Zaslavskij, N. P. Luznaja, S. S. Sinani, M. J. Tissen, G. V. Ustavščikova, and others.

Upon elimination of identical and related decompositions, as well as of points sharply deviating from equilibrium (due to rainfall, etc.), from a total of 300 lake points, 105 points spread over a number of years were plotted on a diagram of a type represented in Fig. 1. The annual cycles so plotted for five years were reduced in a common diagram to a continuous curve, which, we suggest, should be named a cyclochronogram. From this

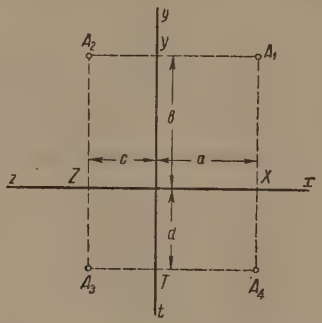

Fig. 1.

diagram we derived both a mean annual cycle for 5 years and two particular cycles: one for the dry years (1934, 1935 and 1936), and one for the wet years (1932 and 1933).

The mean annual cycle curves give time—temperature, $MgCl_2$—Na_2Cl_2—$MgSO_4$, as six projection diagrams along 5 axes, i. e. 6 point for every composition.

In Fig. 2, the arrows show the direction of the cycle's movement in the individual projections. The transverse dashes show the beginnings of the separation, or the termination of the dissolution of the bottom phases, as well as the reciprocal transitions of the solid phases.

We shall now dwell only on the description of the cycle in the most characteristic quadrant, that of temperature—$MgCl_2$. The continuous curve represents the mean annual cycle, the dotted line, the mean cycle of the wet years (1932, 1933), the dash line, the mean cycle of the dry years. We shall begin the description from the mean normal (standard) cycle beginning in May, when only one bottom phase, sodium chloride, is present on the bottom of the sea. In July, when the salt solution evaporates and its temperature increases to 29°, while the $MgCl_2$ content is about 50 molecules, the deposition of «sel mixte» ($NaCl+MgSO_4 \cdot 7H_2O$) begins; a further concentration to 76 molecules of $MgCl_2$ is accompanied by the transition of the septiaqueous hydrate $MgSO_4 \cdot 7H_2O$ into the sexiaqueous hydrate $MgSO_4 \cdot 6H_2O$. The mean maximum of $MgCl_2$ accumulation is 75 molecules at 25°. When the temperature of the brine falls to +10°, the $MgCl_2$ concentration is reduced to 40 molecules. The magnesium sulphate of the sel mixte dissolves being first rehydrated to a septiaqueous salt at a concentration of about 70 molecules. A special stress should be laid on the phenomenon of hysteresis observable in the autumn period during the hydration and dissolution of the sel mixte. This retardation is due to the lowering of temperature, so that the formation of the sel mixte in the polytherm of the reciprocal system may take place at lower $MgCl_2$ concentrations;

the lag is also due to passive resistances to equilibration. From November onwards, the only bottom phase present is again sodium chloride, within a temperature range of +10 to 0°. A further lowering of temperature to —8° and a magnesium chloride concentration of 33 molecules results in the separation of a cryo sel mixte (a new term denoting the mixed salts formed at low temperatures). A continuing dilution of the brine results in the formation of mirabilite at temperatures of —8° to +4° and a $MgCl_2$ concentration of 17

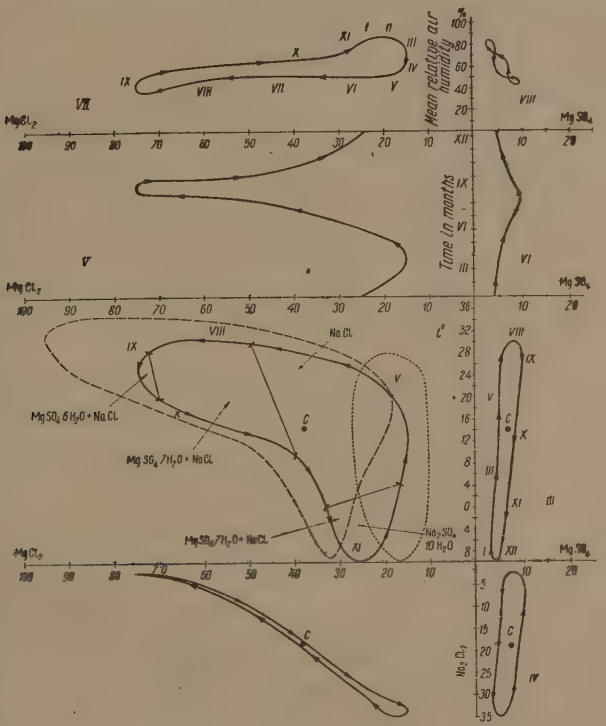

Fig. 2.

to 26 molecules. The subsequent rise in the temperature of the brine brings us again to NaCl as the only bottom phase and to the closing of the annual cycle.

There are two distinct periods in the existence of NaCl as the only bottom phase. The fisrt of them lasts from middle March to July and involves concentrations of 15 to 50 molecules of $MgCl_2$ and temperatures of +4 to +29°, while the second one, described above, lasts from November to December. Another point to be noted is the precipitation of mirabilite jointly with sodium chloride bihydrate at —8° and a $MgCl_2$ concentration of 29 molecules, as well as the precipitation of sodium chloride bihydrate at a $MgCl_2$ concentration of 36 molecules and a temperature of —10°. No ice precipitation was observed throughout the period of 1932—1936 which is in full agreement with the polytherm data of the mutual system.

For the dry year annual cycle (dash line in Fig. 2), the magnesium chloride concentration ranges from 19 to 95 molecules, and the temperature from —10 to +35°. In this cycle, the region of the existence of the sel mixte with $MgSO_4 \cdot 6H_2O$ becomes expanded, whereas the region of mirabilite formation decreases to vanishing point in the winter period.

For the wet year annual cycle, the $MgCl_2$ concentration ranges from 12 to 28 molecules, and the temperature from +28 to —10°. During the winter period, at temperatures below 0°, only mirabilite is precipitated, and in the summer and autumn period, only NaCl, while no separation whatever of sel mixte takes place.

As to the cycles of the remaining quadrants, we shall mention here only that of the second quadrant: $MgCl_2$—Na_2Cl_2 which is a reproduction of the converging isotherms of the triple system: H_2O—Na_2Cl_2—$MgCl_2$.

As a result of the derivation and analysis of the cyclochronograms of Elton Lake for 5 years of continuous observation, we succeeded in obtaining an unprecedented representation of a full and complete cycle of the lake, expressed in projections of a poly-dimensional diagram and fully agreeing with the polytherm of the reciprocal system Na, Mg‖Cl, SO_4. We also arrive at a conception of the mean composition of the salt lake and of the temperature of the salt solution, which may be taken for Elton Lake to be 18 Na_2Cl_2 molecules, 39 $MgCl_2$ molecules, and 7 $MgSO_4$ molecules at a mean temperature of +14.5°. This point is the centre of gravity of the projections of the cyclochronogram, but it is not the true equilibrium composition of the brine (*C*).

The data and laws obtained for the cyclochronogram of Elton Lake may also be extended to other lakes of the sulphate-magnesium type lying in the same climatic zone as Lake Elton (the third climatic zone of Prof. A. A. Kaminskij's classification).

It is to be noted that, in point of composition and coefficient of metamorphism, the salt solution of Lake Elton is not unlike those salt lakes as owe their origin to the evaporation of sea water.

In order to define with greater precision the extreme low and extreme high temperature ranges, the investigations now in progress on Lake Elton should be continued and carried on in greater detail. It is also necessary to make similar investigations of annual cycles for lakes of a different type (those containing magnesium chloride, calcium chloride, sulphates, boron, etc.), and lying in different climatic zones, whether connected or not connected with the sea. Such investigations should certainly comprise Kara-Bugaz and the Perekop lakes. The cyclochronograms derived by the writers are to be used as a method of control in studying the regime of lakes.

The cyclochronograms of lakes, plotted for the main salt components and for the main climatic factors, may serve as a physico-chemical characterization of the climate.

It may be stated in conclusion that the cyclochronograms of lakes, involving the coordinates of time, contribute to the fruitful incorporation of that coordinate into the physico-chemical analysis, which deepens our knowlege of the nature of matter. Besides, the cyclochronograms will prove of great practical value, both in designing salt-productive combinations, and in the course of working the salt mines.

Further investigations of cyclochronograms of lakes and of the physico-chemical characteristics of climate are being carried on.

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CHEMIE

REAKTION ZUR UNTERSCHEIDUNG DES FRUCHTZUCKERS VOM TRAUBENZUCKER

Von E. V. ZMAČINSKIJ

(Vorgelegt von A. E. Favorskij, Mitglied der Akademie, d. 19. IX. 1937)

Gewöhnlich wird zur Unterscheidung des Fruchtzuckers vom Traubenzucker die Seliwanoff-Reaktion empfohlen(1).

Die Reaktion besteht in der Erwärmung einer Zuckerlösung mit konzentrierter Salzsäure und einigen Resorcin-Kristallen; verfärbt sich die Flüssigkeit dunkelrot, so dient dies als Beweis für das Vorhandensein von Fruchtzucker (resp. irgendeiner anderen Ketose).

Diese Reaktion hat den Nachteil, dass man sie auch bei anderen Zuckerarten, wie z. B. bei Rohrzucker und, unter gewissen Voraussetzungen, selbst bei Traubenzucker erhält(2). Man muss daher, um verlässliche Ergebnisse bei Durchführung der Seliwanoff-Reaktion zu erzielen, die für den betrachteten Fall festgesetzten Normen für die Konzentration der Salzsäure, die Resorcin- und Zuckermenge und endlich für die Art und Dauer der Erwärmung innehalten. Hierdurch wird natürlich die Anwendung der Seliwanoff-Reaktion kompliziert.

Es ist daher viel einfacher, wenn man den Unterschied zwischen Frucht- und Traubenzucker veranschaulichen will, die von mir beschriebene Reaktion zwischen Schwefel und α-Oxyketon(3) in der folgenden Abweichung und Durchführung anzuwenden.

In zwei Reagenzgläser bringt man gesondert kleine Mengen der zu untersuchenden Hexose (60—100 mg), schüttet in noch geringeren Mengen Schwefel in Pulverform (10—15 mg) hinzu und giesst in jedes Reagenzgias 1—2 ml Glyzerin und 1—2 Tropfen einer Bleiazetatlösung, worauf beide Reagenzgläser gleichzeitig über einer Gasflamme leicht angewärmt werden. Einige Sekunden später wird das Fruchtzucker enthaltende Reagenzglas sich schwarz färben, während die Flüssigkeit in dem Reagenzglas mit Traubenzucker sich nicht verändern wird*. Die Anwärmung darf nicht lange dauern, da infolge einer wahrscheinlichen Isomerisierung des Traubenzuckers in Fruchtzucker eine Schwarzfärbung der Flüssigkeit auch in dem anderen Reagenzglas erfolgen wird.

Die Schwarzfärbung, die für die geschilderte Reaktion auf Fruchtzucker kennzeichnend ist, erklärt sich aus der Bildung von Bleisulfid auf Kosten

* Man gelangt zu den gleichen Ergebnissen, wenn man zum Vergleich mit Fruchtzucker Rohr-, Milch- oder Malzzucker verwendet.

des Azetats und Schwefelwasserstoffs, der bei der Reaktion des Schwefels mit dem Fruchtzucker ausgeschieden wird.

Man muss annehmen, dass die Reaktion analog ist der Reaktion von Schwefel mit Benzoin*:

$$CH_2OH \cdot CHOH \cdot CHOH \cdot CHOH \cdot CO \cdot CH_2OH + S = H_2S + \\ + CH_2OH \cdot CHOH \cdot CHOH \cdot CO \cdot CO \cdot CH_2OH^{**}$$

Traubenzucker geht keine Reaktion mit Schwefel ein, sofern in ihm die Gruppe—CHOH—CO— fehlt.

Zusammenfassung

1. Beschrieben wird eine Reaktion zur Unterscheidung von Fruchtzucker und Traubenzucker, darin bestehend, dass Fruchtzucker im Gegensatz zu Traubenzucker in der Reaktion mit Schwefel nach kurzer Erwärmung in Glyzerin, das Bleiazetat enthält, schwarzfarben wird. Ursache ist die Bildung von Bleisulfid auf Kosten des Azetats und des Schwefelwasserstoffes, der bei der Reaktion des Schwefels mit der Ketose ausgeschieden wird.

2. Es wird die Vermutung ausgesprochen, dass die Reaktion von Schwefel und Fruchtzucker analog der Reaktion von Schwefel mit Benzoin verläuft, d. h. eine Oxydation der sekundären Alkoholgruppe zur Folge hat, die neben Karbonyl steht, was zu der Bildung von Diketoalkohol-Hexan-Tetrol-(1.4.5.6)-on-(2.3), $CH_2OH—CHOH.CHOH.CO.CO.CH_2OH$, führen muss.

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* Benzoin geht, wie dies in der vorigen Arbeit aufgezeigt wurde, fast quantitativ in Benzil über nach der Formel: $C_6H_5.CHOH.CO.C_6H_5+S=C_6H_5CO.CO.C_6H_5+H_2S$.

** Ich erachte die Bildung einer Verbindung $CH_2OH.CHOH.CHOH.CO.CO.CH_2OH$—Hexantetrol-(1. 4. 5. 6)-on-(2.3) für möglich; sie ist in der chemischen Literatur nicht beschrieben, da alle für Fruchtzucker verwendeten Oxydationsmittel entweder Oxydationsprodukte mit weniger als sechs Atome Kohlenstoff ergaben, oder auf die erste Alkoholgruppe einwirkten, diese in die Aldehydgruppe überführten und die Verbindung $CH_2OH.CHOH.CHOH.CHOH.CO.CHO$—Hexantetrol-(3.4.5.6)-on-(2)-al-(1) ergaben.

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PETROGRAPHIE

DER ZUSAMMENHANG ZWISCHEN DER VISKOSITÄT GESCHMOLZENER GESTEINE UND DEM AZIDITÄTSKOEFFIZIENTEN NACH F. J. LOEWINSON-LESSING

Von M. P. VOLAROVIČ und L. I. KORČEMKIN

(Vorgelegt von F. J. Loewinson-Lessing, Mitglied der Akademie, d. 22. X. 1937)

In einer der früheren Arbeiten haben die Verfasser(1) gezeigt, dass die Viskosität der geschmolzenen Laven vom Vulkan Alages (aus der Sammlung von P. I. Lebedew) in bestimmter Weise mit ihrem Aziditätskoeffizienten nach F. J. Loewinson-Lessing verknüpft ist. Ferner wurde gezeigt(2), dass für 18 Proben von Eruptivgesteinen, von denen drei Basalte aus der Arbeit des japanischen Gelehrten K. Kani(3) stammen, die Punkte auf dem den Logarithmus der Viskosität ($\log\eta$) mit dem Aziditätskoeffizienten α verbindenden Diagramm mit genügender Annäherung auf einer fliessenden Kurve liegen. Hierbei variieren die α-Werte von 1.5 bis 4.5, während sich die Viskosität von 50 bis 10^7 Poisen verändert.

Gegenwärtig ist es uns gelungen, diese Abhängigkeit auf ein Material von 33 Gesteinsproben zu erweitern, deren Viskosität von verschiedenen Verfassern gemessen wurde, wobei zu erwähnen ist, dass alle Forscher bei der Messung der Viskosität sich der Methode des rotierenden Zylinders bedienten.

In der Tabelle ist der Ursprung der Gesteine, ihre chemische Analyse sowie die α- und $\log.\ \eta$- Werte bei $t = 1400°$ C angegeben.

In derselben Tabelle sind auch Daten für einige Mineralien und synthetische Schmelzen angegeben.

Wenn die Abhängigkeit ($\log\eta$—α) für eine Serie von Gesteinen eines magmatischen Herdes ziemlich gut durch eine fliessende Kurve dargestellt wird(1), so liegen im Falle von Gesteinen verschiedener petrographischer Provinzen, wie aus dem Diagramm (Abbildung, s. 421) zu ersehen ist, die Punkte etwas verstreut: immerhin gruppieren sie sich doch bestimmt in Gestalt eines mehr oder weniger breiten Streifens um die auf der Abbildung ausgezogene Kurve*. Diese Kurve entspricht der folgenden Näherungs-Gleichung: $\log \eta_{1400°} = -\frac{c}{\alpha + b} + d$, wo $c = 23.3$ und $b = 1.1$ empirische Konstanten sind. Die Konstante d ist aus der Bedingung $\alpha = \infty$ zu bestimmen. Da man annehmen kann, dass fur Quarzglas $\alpha = \infty$, so ist $d = \log \eta_{1400°}$ für Quarzglas, d. h. $d = 10.5$ (s. Tabelle, № 23). Somit nähert sich die Kurve asymptotisch dem Werte $d = 10.5$. Durch punktierte Linien ist auf der Abbildung das Gebiet abgegrenzt, innerhalb dessen die Viskosität fast aller von uns angeführten Gesteinsproben eingeschlossen ist.

Auf diese Weise kann man die Viskosität des Gesteins bei 1400° für jeden gegeben α-Wert annähernd nach der Formel:

$\log \eta_{1400°} = -\frac{23.3}{\alpha + 1.1} + 10.5 + n$, berechnen, wo $n = \pm 0.5$ die Entfernung der punktierten Linien von der zwischen ihnen liegenden Kurve ist.

* Diese Kurve ist nicht ganz ähnlich derjenigen, welche wir in der Mitteilung auf dem XVII. Internationalen Geologischen Kongress angeführt haben (9).

Tabelle

№	Gesteinsart	α	log η bei 1400°	SiO_2	TiO_2	Al_2O_3	Fe_2O_3	FeO	MgO	CaO	Na_2O	K_2O	MnO	$H_2O_{(+)}$	$H_2O_{(-)}$	
	Von M. P. Volarovič und Mitarbeitern untersuchte Gesteine															
1	Basalt aus Transkaukasien (Erevan) von A. A. Januschkewitsch	1.47	1.75	49.03	1.02	17.72	5.68	4.39	3.78	8.68	2.54	7.46	0.17	0.15		SO_3—0.89 0.75*
2	Teschenit Kursebi von A. A. Januschkewitsch	1.75	2.94	50.58	0.66	18.89	4.52	6.41	1.80	7.76	2.29	0.79	0.24	—	—	P_2O_5—0.29 SO_3—1.19 3.43*
3	Andesit vom Kasbek von A. A. Januschkewitsch	2.53	3.08	63.76	0.44	17.81	5.53	0.59	3.72	5.05	0.67	0.66	0.09	—	—	SO_3—1.56
4	Diabas № 1 aus Schelika, in der Moskauer Steingussfabrik umgeschmolzen	1.52	1.79	48.14	0.96	12.86	7.31	10.62	6.12	9.18	4.18	0.66	0.08	—	—	—
5	Olivinbasalt, Kljutschevskaja Sopka, Kirguritch Strom	1.71	2.1	52.40	0.79	15.28	2.14	6.36	8.87	9.45	2.89	0.34	0.14	0.11		1.74*
6	Obsidian aus der Umgebung von Erevan (Suchoj Fontan)	4.38	5.24	73.79	0.16	13.77	0.40	0.78	0.08	1.06	4.14	5.13	0.08	—	0.08	0.33*
7	Glas aus Trachyte, mit Beimengungen geschmolzen von I. I. Kitajgorodsky	3.93	2.58	62.8	0.03	12.69	0.80	—	—	15.56	5.67	3.32	—	—	—	—
8	Diorit (Krasnouralsk) von W. W. Arschinow	1.8	2.85	53.83	0.58	18.13	3.58	5.21	3.87	8.68	2.73	1.49	0.29	1.67	0.17	P_2O_5—0.05
9	Lava vom Vesuv (4)	1.50	2.4	47.79	1.02	17.72	5.68	4.39	3.78	8.68	2.54	7.46	0.17	0.15		—
10	Basalt vom Alagez von P. I. Lebedew	1.61	2.556	50.92	1.60	17.81	3.96	5.12	6.10	8.43	3.55	1.88	0.11	0.49	0.19	—

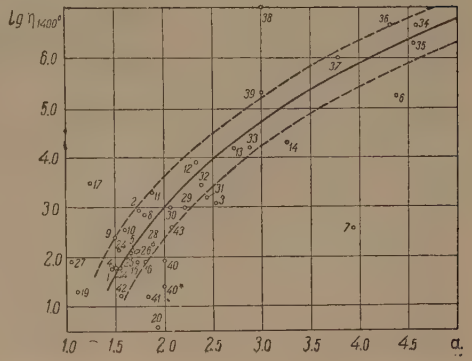
11	Andesitbasalt vom Alagez von P. I. Lebedew	1.88	3.297	55.15	0.88	17.22	1.64	4.85	6.09	7.91	3.56	1.74	0.12	0.94	—	
12	Andesit vom Alagez von P. I. Lebedew	2.33	3.895	59.44	0.91	16.02	1.68	4.96	3.47	5.66	4.08	2.28	0.09	0.72	0.65	—
13	Dacit vom Alagez von P. I. Lebedew	2.72	4.182	63.85	0.87	16.58	3.24	1.65	1.52	3.16	4.35	4.29	0.08	0.46	0.13	—
14	Alkalischer Dacit vom Alagez von P. I. Lebedew	3.26	4.312	66.30	1.09	11.88	2.83	4.20	1.10	2.70	6.19	3.73	0.14	—	—	P_2O_5—0.23 1.10*
15	Diabas № 101 aus Schelika	1.81	1.900	51.63	1.98	12.96	4.01	11.97	4.56	8.54	2.75	1.34	0.22	0.20		SO_3—0.19
16	Diabas № 103 aus Schelika, in der Moskauer Steingussfabrik umgeschmolzen	1.73	1.900	50.88	1.99	11.94	7.54	10.03	5.40	3.67	2.54	1.29	0.21	—	—	—
17	Urtit von der Halbinsel Kolskij, von O. A. Worobjewa	1.04	3.5	43.68	0.19	28.23	2.70	0.28	0.18	2.80	15.10	3.34	0.07	0.12		Cl—0.07 P_2O_5—1.78 S—0.06 F—0.04 0.79*
18	Ägiringestein von O. A. Worobiewa	—	2.0	—	—	—	—	—	—	—	—	—	—	—	—	—
19	Synthetische Schlacke (M. Wolarowitsch und L. Zwerew)	1.11	1.3	40.98	—	15.00	—	0.48	—	43.86	—	—	—	—	—	—
20	Schlacke № 1276/2 (4)	1.92	0.6	47.89	—	5.43	—	21.02	0.47	1.59	4.58	0.58	18.16	—	—	—
21	Glas (M. Wolarowitsch und D. Tolstoi) (4)	6.2	2.6	73.5	0.06	0.6	0.16	—	1.38	4.3	14.0	3.5	—	1.06		SO_3—0.5
22	Glas von I. I. Kitajgorodsky	6.89	2.5	73.42	—	0.86	0.31	—	0.14	4.99	10.48	5.88	—	—	—	PbO—4.22
23	Quarzglas	—	10.5	99.9	—	—	—	—	—	—	—	—	—	—	—	—

* Erhitzungsverlust.

Fortsetzung

№	Gesteinsart	α	log η bei 1400°	SiO_2	TiO_2	Al_2O_3	Fe_2O_3	FeO	MgO	CaO	Na_2O	K_2O	MnO	$H_2O_{(+)}$	$H_2O_{(-)}$	
	Von K. Kani [5] untersuchte Gesteine															
24	Olivinbasalt Gembudo	1.54	2.14	49.29	2.22	18.49	2.38	6.77	6.09	8.14	3.93	1.79	0.22	0.88		—
25	Olivinbasalt Kônoura	1.66	2.08	49.24	1.33	16.81	6.16	3.60	8.02	9.49	2.67	1.09	0.17	1.50		P_2O_5—0.43
26	Andesitbasalt Motomura	1.73	2.13	51.80	0.60	15.0	3.68	10.14	5.36	9.77	1.76	0.22	0.20	0.62		P_2O_5—0.31
27	Nephelinbasalt Nagahama	1.05	1.91	35.66	3.74	11.97	5.19	9.69	8.35	14.39	3.65	1.89	0.30	4.04		P_2O_5—1.37
28	Augitandesit Miyakójima	1.89	2.25	53.27	1.87	14.38	5.41	8.65	1.61	10.97	1.93	0.90	0.35	0.16		P_2O_5—0.12
29	Zweipyroxenischer Andesit Asama-yama	2.22	3.0	59.90	0.05	15.99	2.86	4.77	4.68	6.08	3.39	1.28	0.89	0.58		—
30	Zweipyroxenischer Andesit Tarumaé	2.07	3.0	57.4	0.65	16.84	3.68	5.96	3.28	6.60	2.88	1.21	1.08	0.36		S—0.02
31	Zweipyroxenischer Andesit Komagadaké	2.44	3.2	61.41	0.46	15.42	2.64	4.93	2.34	6.70	4.72	1.10	—	0.52	0.02	—
32	Zweipyroxenischer Andesit Sakurajima	2.39	3.45	60.80	0.87	16.04	2.89	4.63	3.50	4.74	3.74	1.75	0.33	0.74		S—0.01
33	Hornblende - Glimmerandesit Unzen	2.88	4.2	65.15	0.05	14.25	3.27	2.50	2.36	4.60	3.80	2.52	0.56	0.90		—
34	Pechstein Arita	4.59	6.65	70.26	—	12.25	0.27	0.86	0.32	0.97	4.24	3.60	0.03	5.44	1.10	P_2O_5—0.17
35	Hornblendegranit Sumiyoshi	4.56	6.3	75.23	0.15	13.69	0.50	1.03	0.49	1.32	3.25	3.19	0.09	0.96		P_2O_5—0.21 ZrO_2—0.03
36	Liparit Niijima	4.32	6.65	75.90	—	15.41	0.36	0.22	0.21	0.84	4.41	2.88	—	0.08		—

37	Obsidian Oki	3.78	6.0	71.37	0.04	14.72	1.08	1.38	0.35	1.36	3.74	5.69	0.06	0.33	0.10	P_2O_5—0.12
38	Synthetischer Orthoklas	3	7.009	64.72	—	18.35	—	—	—	—	—	16.93	—	—	—	—
39	Synthetischer Albit	3	5.250	68.68	—	19.48	—	—	—	—	11.84	—	—	—	—	—
40	Synthetischer Diopsid	2	1.903 1.415**	55.58	—	—	—	—	18.58	25.84	—	—	—	—	—	—
	Von A. Ginsberg (7) untersuchte Gesteine															
41	Olonetzker Diabas	~1.70	1.22	—	—	—	—	—	—	—	—	—	—	—	—	—
42	Trapp aus Tulun	1.56	1.23	47.04	1.85	15.48	2.84	10.12	6.24	8.61	2.45	0.63	—	—	—	4.4*
	Von G. Zhukowskij (8) untersuchte Gesteine															
43	Olonetzker Diabas	2.07	2.6	56.47	0.93	16.02	5.22	5.83	3.30	5.96	2.84	2.35	—	—	—	SO_3—0.64 Mn_3O_4—0.22 0.11*
44	Basalt aus Transkaukasien (Erevan)	1.55	1.78	49.38	1.33	15.55	4.74	7.54	6.59	10.19	3.83	—	—	—	—	SO_3—0.18 Mn_3O_4—0.08 0.18*



* Erhitzungsverlust.

** Zahl 1.415 für Diopsid ist aus der Arbeit fon MacCaffery genommen (6).

K. Kani und K. Gosakova versuchten einen Zusammenhang zwischen der Viskosität der Gesteinsschmelzen und dem SiO_2-Gehalt festzustellen. Wir überzeugten uns jedoch davon, dass in dem Diagramm $\log\eta$—SiO_2 die Punkte bedeutend stärker streuen als in dem Diagramm $\log\eta$—α. Das ist verständlich: obzwar die Viskosität der Schmelzen in erster Linie durch den Kieselsäuregehalt bedingt ist, so spiegelt der Aziditätskoeffizient α den Chemismus der Gesteine besser wider, als nur die SiO_2-Menge in demselben.

Es ist interessant, dass L. W. Zwerew und Kaufmann[10] beim Auftragen der Abhängigkeit der Viskosität vom SiO_2-Gehalt in einem Diagramm für eine Reihe von Schweisschlacken eine im allgemeinen fliessende Kurve erhielten. Es ist zu erwähnen, dass nach Angabe der Verfasser der Gehalt der in den Schlacken enthaltenen Oxyde (ausser SiO_2) innerhalb bestimmten Grenzen schwankt, die den Cr_2O_3 enthaltende Schlacken sich dagegen nicht in die erhaltene Kurve einreihen lassen.

Bedeutende Abweichungen von der Viskositätsisotherme ergaben sich bei uns für den Nephelinbasalt von K. Kani № 27, sowie für den von A. S. Ginsberg und F. G. Semenow gemessenen Diabas. Die Daten für die Viskosität der Probe № 41 erscheinen etwas zu klein zu sein. Ebenso kann auch die Viskositätszahl für den von uns gemessenen Obsidian № 6 nicht als genau betrachtet werden, infolge der grossen Schwierigkeiten bei Messung einer derartig enormen Viskosität in unserem Apparat.

Anderseits erwiesen sich bei dem Versuch, in dieses Diagramm auch die Daten für monominerale Gesteine und synthetische Silikatschmelzen (Schlacken, Gläser, Gesteine mit Beimengungen) einzutragen, alle Punkte ausserhalb des durch die punktierte Linie begrenzten Gebiets. Wenn auch die Schlacken № 19, № 20 nicht allzu weit abweichen, ebenso wie Albit № 39 und Diopsid № 40 nach den Angaben von Kani, so kamen Orthoklas № 38, der mit Beimengungen geschmolzene Trachyt № 7, das monominerale Gestein Urtit (von O. A. Worobjewa) in bedeutenden Entfernung zu liegen, und die Gläser № 21 und № 22 fanden in den Grenzen unseres Diagramms überhaupt keinen Platz.

Wie aus der Abbildung su ersehen ist, sind die Variationen der viskosität fur einen bestimmten Wert ziemlich gross (man muss in Betracht ziehen, dass auf der Ordinatenachse der Logarithmus des Viskosität aufgetragen ist), was durch die Veränderung des Verhältnisses der, ausser SiO_2, in den Gesteinen mit dem gleichen Aziditätskoeffizienten α- enthaltenen Oxyde bedingt ist. Immerhin illustriert die von uns für die Schmelzen der polymineralen eruptiven Gesteine angeführte Viskositätsisotherme, die graphisch in Gestalt eines mehr oder weniger breiten Streifens dargestellt ist, die bekannte Tatsache, dass die Schwankungen der Oxyde in solchen Gesteinen durch bestimmte Grenzen beschränkt sind.

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PETROGRAPHIE

UNTERSUCHUNGEN DER VISKOSITÄT DER OBSIDIANE IM ZUSAMMENHANG MIT DER FRAGE DER GENESIS DES BIMSSTEINES

Von M. P. VOLAROVIČ und A. A. LEONTJEVA

(Vorgelegt von T. J. Loewinson-Lessing, Mitglied der Akademie, d. 22. X. 1937)

Gewöhnlich stellen die sauren Bimssteine unter dem Mikroskop ein poröses Glas dar, in dem in geringer Menge Kriställchen des Plagioklases enthalten sein können. Ihrer chemischen Zusammensetzung nach stehen solche Bimssteine den Obsidianen nahe (1). Auf Grund dessen stellt man sich gegenwärtig die Genesis des Bimssteines meist folgendermassen vor: während der Eruption des sauren Magma, das eine bedeutende Menge flüchtiger Komponenten, insbesondere Wasserdämpfe, enthält, bilden die Gase im Zusammenhang mit der plötzlichen Herabsetzung des Druckes, in der glasartigen Masse Bläschen, die die Porosität des Bimssteines bedingen.

A. Brun (2) erhielt durch Erhitzung von Obsidianen auf künstlichem Wege eine bimssteinartige Masse. Derartige Versuche führte auch K. Endell (3) aus. M. Goldschlag (4) hebt hervor, dass zuerst A. Humboldt auf die Möglichkeit der Bildung von Bimsstein aus Obsidian hingewiesen habe und dass G. Abich noch vor A. Brun dies experimentell nachgewiesen habe. Im Zusammenhang mit unseren früheren Arbeiten über die Viskosität geschmolzener Gesteine erschien es uns von Interesse, die Grenzen der Viskosität, innerhalb deren aus geschmolzenem Obsidianglas Bimsstein entstehen kann zu bestimmen.

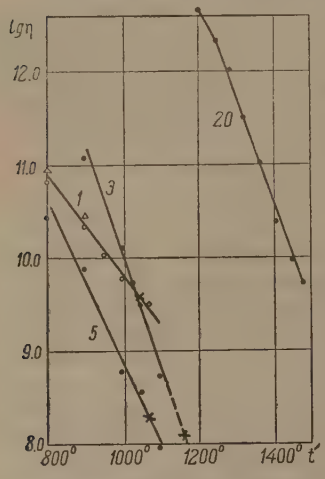
Für die Versuche benutzten wir die etwas veränderte Methode, die wir früher zur Messung der Viskosität des Quarzglases im Erweichungsintervall benutzten (5). Zu diesem Zweck schnitten wir aus dem Obsidian mittels einer Diamantsäge eine Probe* in Gestalt eines Prismas mit quadratischem Querschnitt ($8\times2\times2$ cm^3) heraus. Aus dem mittleren Teil des Prismas sägten wir mittels Karborundum einen schmäleren Teil von 1 cm Länge und mit einem Querschnitt von 0.8×0.8 cm^2 heraus. Die Probe wurde in einen vertikalen Röhrenofen mit Platinwickelung gebracht, wobei die Temperatur im mittleren Teil des Ofens auf einer Strecke von 2 cm Länge genügend konstant war und mittels eines Pt-Pt/Rh-Thermoelements gemes-

* Die Prismen aus den Obsidianen wurden im Laboratorium für Baumaterialien des Petrographischen Instituts hergestellt.

sen wurde. Der obere und untere Teil der Probe (Obsidian) befanden sich ausserhalb der Wickelung des Ofens: die Enden der Probe waren in spezielle Federstahlklammern eingeklemmt, zu welchem Zwecke von zwei Seiten des Obsidianprismas Kanälchen eingesägt waren. Die obere Klammer diente zum Aufhängen der Probe auf einem massiven Stativ, an die untere Klammer wurde dagegen ein Gewicht angehängt.

Indem mittels Mikroskop die Dehnungsgeschwindigkeit der Probe bei konstanter Temperatur beobachtet wird, kann, wenn die Grösse des Gewichtes und die Masse der Probe bekannt sind, die Viskosität berechnet werden (6). Hierbei muss man berücksichtigen, dass nur der schmale mittlere Teil der Probe sich dehnt, was nach Beendigung des Versuches klar zu sehen ist.

Nach der beschriebenen Methode wurde die Viskosität von drei Proben vulkanischer Gläser gemessen: № 1—Obsidian aus der Kollektion von B. M. Kupletsky (7) vom Berge Grosser Ach-Dag (Achmangansky Plateau), № 3—Obsidian aus der Kollektion von P. I. Lebedew (8) vom Vulkan Alages, № 5—Obsidian aus dem Suchoj Fontan in der Nähe von Erewan*.



Die Messergebnisse sind graphisch auf der Abbildung dargestellt, wo auf der Abszissenachse die Temperatur und auf der Ordinatenachse der Logarithmus des Viskosität (die Viskosität in Poisen ausgedrückt) aufgetragen ist. Durch Kreise und Dreiecke sind die Ergebnisse zwei unabhängiger Messungen des Obsidians № 1 eingetragen: die Übereinstimmung kann als befriedigend bezeichnet werden, wenn man die geringe Genauigkeit derartiger Versuche in Betracht zieht. Die Temperaturabhängigkeit vom $\log\eta$ erweist sich bei dem Obsidian fast geradlinig.

Auf der Abbildung ist zum Vergleich die Kurve (№ 20) der Viskosität des Quarzglases angefürht. Wie man sieht, ist die Viskosität des Obsidians um vieles geringer als die des Quarzglases, was durch den bedeutenden Gehalt an Alkalien im Obsidian, sowie durch das Vorhandensein flüchtiger Komponenten zu erklären ist. Uns scheint der Wert der beschriebenen Methode darin zu bestehen, dass die Messungen an einer Probe eines natürlichen, nicht umgeschmolzenen, flüchtige Komponenten enthaltenden Gestein ausgeführt wurden.

Ferner wurden durch besondere Versuche die Temperaturen bestimmt, bei denen die Bimssteinbildung erfolgt. Zu diesem Zweck wurden kleine Obsidianstückchen in einem Porzellantiegel in den Ofen gebracht und mit einer Geschwindigkeit von 10° in der Minute erhitzt. Hierbei konnte die Temperatur, bei der eine steile Volumenvergrösserung der Proben eintrat, mit einer Genauigkeit von $\pm 10°$ bestimmt werden. Die entsprechenden Temperaturen für die drei von uns untersuchten Obsidiane sind auf der Abbildung durch Kreuze bezeichnet.

Die Schliffe der Obsidiane und bimssteinartigen nach der Erhitzung enthaltenen Proben wurden mikroskopisch untersucht. Hierbei stellte es sich heraus, dass der Obsidian № 3 ein kompaktes durchsichtiges Glas ist. Die der Erhitzung unterworfene Proben stellen eine blasige, glasartige, an den

* Die Verfasser sprechen den Professoren B. M. Kupletskij und P. J. Lebedew ihren herzlichsten Dank für die liebenswürdige Überlassung der Obsidianproben aus.

gewöhnlichen Bimsstein stark erinnernde Masse dar. Die Obsidiane № 1 und № 5 enthalten inmitten des Glases eine kleine Menge kristallischer Bildungen, offenbar Feldspatkristalle. Die Menge der Kristalle, sowie der Charakter derselben, verändern sich nach der Erhitzung nicht.

Es ist interessant, dass einige Prismen zum Schluss des Versuchs zur Bestimmung der Viskosität bei hohen Temperaturen den Prozess der Bimssteinbildung zeigten. Auf den parallel zur Richtung der Prismendehnung ausgeführten Schliffen sind Gasbläschen länglicher Form gut zu sehen, was häufig auch im natürlichen Bimsstein beobachtet wird.

Wendet man sich der Frage der Genesis des Bimssteines zu, so kann man auf Grund der Betrachtung der Abbildung folgende Schlüsse ziehen. Die Bimssteinbildung erfolgt bei wesentlich höheren Temperaturen, als diejenigen, bei denen die Obsidiane eine visköse Strömung zu zeigen beginnen. Für die Obsidiane № 1 und № 5 gelang es die Viskosität bei $t=800°$ zu messen, während eine Bimssteinbildung erst bei einer Temperatur von etwa 1040 und 1070° beobachtet wurde. Obsidian № 3 besitzt eine noch höhere Temperatur der Bimssteinbildung und zwar 1170°. Somit haben die Gase bei einer Viskosität der Grössenordnung von 10^{11}—10^{10} Poisen noch keine Möglichkeit, aus den Obsidianen auszuscheiden, und erst bei einer Abnahme der Viskosität bis auf 10^{9}—10^{8} Poisen erfolgt eine plötzliche Ausscheidung von Gasbläschen.

Im Zusammenhang mit dem Obengesagten ist anzunehmen, dass, wenn saures Magma von entsprechenden Zusammensetzung sich bei einer Temperatur unterhalb von 1000° ausfliesst, dasselbe in Gestalt von Obsidianglas erstarrt. Wenn dagegen die Temperatur des Magma 1100—1200° erreicht, so werden bei der Eruption desselben infolge der Verringerung des Druckes die Gase ausgeschieden und es bildet sich Bimsstein.

Zum Schluss sprechen wir unsern aufrichtigen Dank Prof. D. S. Beljankin für eine Reihe wertvoller Ratschläge, die wir bei der Ausführung der vorliegenden Arbeit erhielten, aus.

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GENETICS

THE SIZE OF *NICOTIANA RUSTICA* L.×*NICOTIANA TABACUM* L. HYBRID EMBRYOS AND HYBRIDS IN RESPECT TO THEIR PARENTS

By DONTCHO KOSTOFF

(Communicated by N. I. Vavilov, Member of the Academy, 1. XI. 1937.)

Ashby ([1],[2]) in studying the problem of hybrid vigor in maize, found a dependence between the size of the hybrid embryos and the hybrid vigor. According to Ashby ([3]) «the final size of a plant is the resultant of the initial size of its primordia and the relative growth rate. Since in relative growth rate the hybrid had no advantage over its parents, size-heterosis must have been due to an initially bigger primordium. In other words, if the rate of compound interest in the hybrid is no bigger, its capital of dividing cells must be higher. The simplest way to measure this capital is to dissect the primordia (plumule and radicle) from the embryo and weigh them. When this was done it was found that the hybrid embryos were bigger than those of either parent, and the size-heterosis observed in these experiments was due solely to the maintenance of this initial advantage in primordial size». He recorded that he has obtained the same results in experimenting with beans and six strains of tomatoes. Ashby ([1],[4]) statements were recently supported by Luckwill ([9]).

In studying the cell size in vigorous and dwarf hybrids Kostoff and Arutiunova ([7],[8]) found that the vigorous hybrids have not larger cells than their parents, consequently, their vigor is attained by more rapid cell division.

What concerns the relation between embryo sizes and «vigor» I found some data in *Nicotiana* species crosses which show that hybrid embryos might be very small, much smaller than the embryos in either parent, nevertheless, the hybrid that develop from them are very vigorous. This phenomenon can be observed in a series of interspecific hybrids in *Nicotiana*. I shall give here, however, as an example, the cross *Nicotiana rustica*×*N. tabacum*.

Hybrid embryos in mature seeds produced by crossing *N. rustica* with *N. tabacum* are very small. A large number of them do not germinate, but even those that do germinate are much smaller than the embryos of either parents. I have crossed flowers of *N. rustica* with pollen of *N. tabacum* and at the same time I selfed flowers from the parental species. The capsules became yellowish thirty days after the crossing and selfing and the seeds dark-brown, which means that they were mature. Such capsules were fixed and from them paraffin sections were made. Then the embryos were measured and the data obtained are given in Table 1.

I raised plants from hybrid seeds *N. rustica*×*N. tabacum* as well as from the pure parental species under equal environmental conditions and the plants were measured at the end of their florescence period (October 8th). It was found that from exceedingly small embryos, very vigorous F_1-hybrids have developed.

I also included in the experiment the amphidiploid *N. rustica-tabacum* plants ($2n = 96$). They also were much larger in size than the parental forms, but somewhat smaller than the F_1-hybrids (Table 2). It should be mentioned here that amphidiploid *N. rustica-tabacum* is not constant ([6]) because it forms quadrivalents, trivalents and univalents during the meiosis which accounts for its greater variability ($\sigma = 3.7$) no matter that for the experiment uniform seedlings were selected, which were morphologically like F_1-hybrids.

Table 1

The Length and the Breadth of the Embryos 30 Days after Pollination (i. e. when It Is Completely Mature)

No	Embryos from species and hybrids	Somatic chromosomes	Length in microns			Breadth in microns		
			n	*M*	σ	*n*	*M*	σ
1	N. *rustica* selfed . . .	48	150	998.5	12.1	150	764.3	9.6
2	N. *tabacum* selfed . .	48	150	684.2	10.5	150	503.7	8.4
3	The cross F_1 (*N. rustica* × *N. tabacum*) . .	48	150	181.7	18.1	150	126.3	15.3
4	Amphidiploid *H. rustica-tabacum*	96	20	936.3	15.6	20	718.2	11.7

Table 2

The Size of the Parental Plants and the Hybrids in Centimetres

No	Species and hybrids	Somatic chromosomes	*n*	*M*	σ
1	*Nicotiana rustica*	48	30	82.8	2.9
2	*Nicotiana tab cum*	48	30	96.2	3.0
3	F_1-hybrids (*N. rustica* × *N. tabacum*)	48	9	148.5	2.9
4	Amphidiploid *N. rustica-tabacum* . .	96	20	128.9	3.7

Hybrid embryos in our case are smaller than those of either parents, because their physiology, in general, and the physiology of development as well, is different from that of the maternal plant. The hybrid embryos *N. rustica*×*N. tabacum* are somewhat foreign for the maternal plant *N. rustica* having 50% of its genetic nature from *N. tabacum*. If the hybrid embryos were not grown on maternal plant they probably would not be as small as they really were. The reactivity of the maternal organism might also suppress somewhat the hybrid embryos in some respects, the latter being somewhat foreign for the mother (cf. [5]).

These ideas were inferred on the basis of the relative size of the normal embryos, hybrid embryos grown in *N. rustica* organism, and the hybrid embryos that develop in the amphidiploids, the latter being considerably larger than those grown in *N. rustica* organism, no matter that they have about the same genetic constitution. Hence the differences in size of amphidiploid embryos and F_1-embryos is not exclusively due to the polyploid nature of the former.

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PLANT PHYSIOLOGY

A POROMETER FOR INVESTIGATIONS UNDER NATURAL CONDITIONS

By G. H. MOLOTKOVSKIJ

(Communicated by A. A. Richter, Member of the Academy, 16. X. 1937)

One of my papers contains a description of a porometer which is a four-sided flask of a capacity of 1800 cm^3(1).

Two glass tubes bent at right angles pass through the rubber stopper inserted into the neck of the flask. One of the tubes is connected by a rubber tube to the chamber fastened to a leaf of the plant. The other tube acts as an aspirator, the weight of the water column contained therein being used to draw the air through the leaf of the plant.

This porometer being described in detail in the paper referred to above, there is no need to dwell upon the subject. I will but mention here that my idea was to adapt it for observations of the condition of the stomata under natural conditions. For this purpose, the porometer was isolated from the influence of outside factors, more particularly from the influence of temperature, being placed in a galvanized tin box filled with water; the tin box was in its turn placed inside a wooden box lined with cotton wool.

Fig. 1.

Such an arrangement, while giving positive results, is, however, too cumbrous (weight about 15 kg) and too difficult of execution to be of much use in the field. Without altering, therefore, the principle underlying the design of the porometer we used for the purpose an ordinary one litre thermos bottle, which very effectively isolates its contents from the influence of outside temperature. Such thermos bottles may be had in sufficient quantity in the shops.

Fig. 1 shows a porometer of this kind, the neck of which is sealed with a rubber with two glass tubes passing through the stopper. The first of these tubes (*A*) is connected by means of a rubber tube (*B*) with a chamber placed on a leaf of the plant. Through the second tube (*C*), which is an aspirator, the water flows into the cylinder (*D*) when the air penetrates into the porometer through the opening stomata. The amount of water collected in the

cylinder gives an indication of the amount of air admitted through one stoma per second. The method of such a determination is fully described in the writer's other papers ([2,3]).

To prevent the evaporation of the drop of water, which sometimes takes a considerable time to form at the end of the aspiring tube, and also to prevent the evaporation of water out of the cylinder, the latter is sealed with a rubber stopper (*E*), through which only the lower aspirator tube of the porometer is allowed to pass. The stopper is also perforated with a minute air-hole to ensure the passage of air. With the same end in view, it is also desirable to coat the surface of the water in the cylinder with paraffin oil.

Our further observations showed that, under natural conditions, the porometer described above is nevertheless affected by outside influences if exposed to the sun for several hours. As may be seen from the table, the temperature of the water in the porometer is apt to rise somewhat, which affects the accuracy of the readings of the latter, owing to the forcing out of an additional amount of water.

We therefore adopted the simple and effective procedure of wrapping the porometer in a thick layer of cotton wool, which was fastened to the latter with thread. A porometer thus wrapped up in cotton wool is shown in Fig. 1 (G), where it is seen to lie on a special support (*H*).

Table

Date and time of day	Temperature of air, C°	Temperature of water, °C	
		in porometer wrapped in cotton wool	in porometer not wrapped in cotton wool
July 22, 1936 10 a. m.	30	22	22
3 p. m.	36	22.5	24.5*
7 p. m.	25	22.5	25.25

This method reduces practically to nought the liability of the water inside the porometer to be affected by the variations of outside temperature.

There is always an appreciable difference in the degeree of heating of the water inside the porometer as compared with the outside air. The heated air, after passing through the stomata and thence into the chamber on the leaf and the rubber tube, penetrates into the porometer and forces therefrom a number of drops of water corresponding to its degree of heating and its volume in the porometer.

In addition to this, the air contained in the rubber tube connecting the porometer with the chamber, is also heated by insolation and by the heat of the surrounding air, and, in bursting into the porometer, is bound to affect, however slightly, the accuracy of its readings.

This takes place even if the porometer is filled with throughly boiled distilled water, which retains an inappreciable amount of air.

To study this phenomenon, which had been observed under field conditions, a special experiment was carried out in the laboratory. A glass capillary, which figured the stomata of the leaf, was inserted into a rubber tube. Part of the rubber tube with the capillary was placed in a thermostat, which kept at a constant level the temperature of the air that penetrated through the capillary into the porometer and forced the water out of the latter.

* 26 drops of water forced into the cylinder.

This experiment showed the dependence of the flow of water out of the porometer on the degree of heating of the air, this dependence becoming more marked as the volume of air in the porometer increases.

To avoid this, the air flowing towards the porometer is cooled. For this purpose, the rubber tube (Fig. 2, *A*) was, at a distance of 20 cm from the glass tube, inserted into another rubber tube (*B*) of a slightly greater diameter. If, in our apparatus, the tube (*A*) used as a core had a lumen of 2 mm, the wider tube (*B*) used as a casing had been so selected as to have a lumen of 12 mm. The latter is 20 cm long, while the place of the thinner tube inserted therein is 20. 2 cm, i. e. somewhat longer than itself. This is done to facilitate the filling of the large cooling tube with the cooling liquid (Fig. 1, *K*).

This piece is cut out of the main tube, two glass tubes (*C*) being inserted on both sides of it; rubber stoppers (*D*) are pulled over those tubes; the

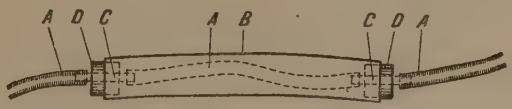

Fig. 2.

stoppers seal the cooling tube when it is filled with the liquid, the main thin tube taking then up a somewhat zigzag-like position.

The glass tube sections (*C*) connected the cooling tube with the remaining portions of the main rubber tube.

The following mixtures of water and salts were used as cooling mixtures:

I.	Powdered ammonium chloride	5 parts
	Powdered potassium nitrate .	5 »
	Water	16 »
II.	Powdered potassium nitrate .	1 part
	Water	1 »

This procedure does away altogether with the noxious effect of the heated air penetrating into the porometer on the flow of water issuing out of it.

It may be mentioned in conclusion that this type of porometer can easily be converted into a self-recording one by adding to it a device a description of which is given in another paper by the same writer (1).

In summing up the above, it may be stated that the porometer described, being handy and accurate in its readings, may conveniently be used in observations of the condition of stomata not only in the laboratory, but also under natural conditions.

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PLANT PHYSIOLOGY

THE INFLUENCE OF THE ALTERNATION OF DAY AND NIGHT ON THE NATURE OF THE VARIATION IN THE DURATION OF THE VARIOUS PHASES OF DEVELOPMENT IN SOY

By G. M. PSAREV

(Communicated by A. A. Richter, Member of the Academy, 16. X. 1937)

While studying the phenomena of photoperiodism in plants, most investigators have so far confined themselves to what may be termed «vegetative» growth and the period of transition of the plant into the reproductive stage. The nature of the subsequent course of development of the plant, involving fruiting and the formation of the most valuable part of the crop, i. e. the seed, has so far been practically left out of consideration as far photoperiodism is concerned.

All the regularities of photoperiodism, however, first established by Garner and Allard(1) and subsequently confirmed and developed by other investigators, but mainly affecting the intial stage of development, have now been applied by some writers to the rate of development in the subsequent life of the pfant [Lubimenko (2), Lubimenko and Ščeglova(3)].

Suggestions are sometimes put forward as to the gradual weakening of the photoperiodic after-effect towards the end of the vegetative period Čailachjan (4).

This conception of the essence of the photoperiodic response appears to be traceable to two causes: first, to the more general view held by the majority of investigators that the photoperiodism of plants is a reaction mainly displayed in the sexual reproduction of plants [Garner (5), Čailachjan (4,6), Maksimov (7), and others]; second, to the long-established view of horticulturists that the total length of the vegetative period depends on the earing or flowering time of a particular plant [Stebut (8), Kuznecova (9), and others].

The investigations of photoperiodism in some cultivated plants (soy-pea, maize and sorgo), begun by the writer in 1931, had for their object to ascertain the nature of the variation in the length of different periods of growth under the influence of the alternation of day and night.

The results of the experiment made in 1935 are set forth below. The experiment was carried out in vegetation vessels. Two plants were grown in each vessel, the experiment being repeated twice. The duration of illumination was as follows: a) 8 hours, b) 10 hours, c) 12 hours, d) natural and e) 18 hours.

The shortening of the day was brought about by placing the vessels containing the plants into a dark chamber for the following periods of time: a) from 4 p. m. to 8 a. m. if the illumination lasted 8 hours; b) from 5 p. m. to

7 a. m. if the illumination lasted 10 hours and c) from 6 p. m. to 6 a. m. if the illumination lasted 12 hours. The long 18-hour day was made up of daylight and of additional electric illumination, the latter being supplied by ordinary 1000-watt incandescent lamps suspended over the plants. Three lamps were suspended in each chamber of an area of 8.75 m^2.

The nature of the variations in the total length of the vegetation period induced by the varying length of the day in the same variety does not coincide with the nature of the phase variations from sprouting to flowering, which is to be put down to the differences in the nature of the variations in the subsequent periods of development in each of the varieties under test.

The following general regularity may be said to exist for all the varieties of soy. An increase in the length of the day and a corresponding decrease of the night over 12 hours produces a simultaneous lengthening of the following phases of development: a) from sprouting to beginning of flowering, b) from beginning to end of flowering, c) from beginning of flowering to formation of beans and d) from formation of beans to beginning of ripening. Each variety, however, exhibits individual peculiarities as to the rate of increase of the duration of every phase under investigation.

Quite different are the variations in the duration of the ripening period induced by the alternation of day and night. A shortned day and a correspondingly lengthened dark period were found to retard the rate of ripening in most varieties of soy-plant under test; inversely, a lengthened day and a shortened night reduce the period of ripening. Natural day produced the greatest shortening of the ripening period in almost all the varieties under test. A lengthened ripening period induced by a long 18-hour day as compared with the natural day is due to differences in the growth energy of the plants and in the rate of the foliation process during the flowering period. While the gradual decrease of the natural day causes the phenomena of growth and those of foliation rapidely to come to an end, those phenomena go on for a considerable length of time if the day is a long one.

The above facts show that, in the first place, the degree of variation of the phase rhythm of development due to changes in the length of day is different in different varieties tested, and, in the second place, the response of the soy plant to photoperiodic exposure exhibits different characteristics from the point of view of the formation of generative organs and the duration of the ripening period.

In order to convey an idea of the nature of the variations induced in the phase rhythm of development by changes in illumination, the durations of individual phases of development in certain varieties have been represented graphically.

With this end in view, the durations of these phases of development were first calculated in relative figures, the duration of each phase of development of each variety tested being taken at 100% under a 10-hour day.

Illini and Manchzhurskaya № 6936, two varieties of soy differing considerably as to the nature of their photoperiodic response, had been selected to illustrate graphically the changes in the duration of the phases of development, the variants of illumination being: 10 hours, natural and 18 hours.

An analysis of the data summarized above suggests the following conclusions:

1. The photoperiodic response of the soy plant is observable at all the stages of the vegetation period, the nature and the degree of the response to change in the length of day and night being different in the different phases of development of the soy plant.

2. The response of the soy plant to a shortened day involves the

shortening of the initial stage of development (the flowering period), and, under certain conditions, of the middle stage of development (the periods of flowering and formation of beans), and also the retardation of the last stage of development i. e. the process of ripening. The response of soy to a lengthened day involves the retardation of the initial, and, under certain conditions, of the middle stage of development and a shortening of the ripening process of the plant.

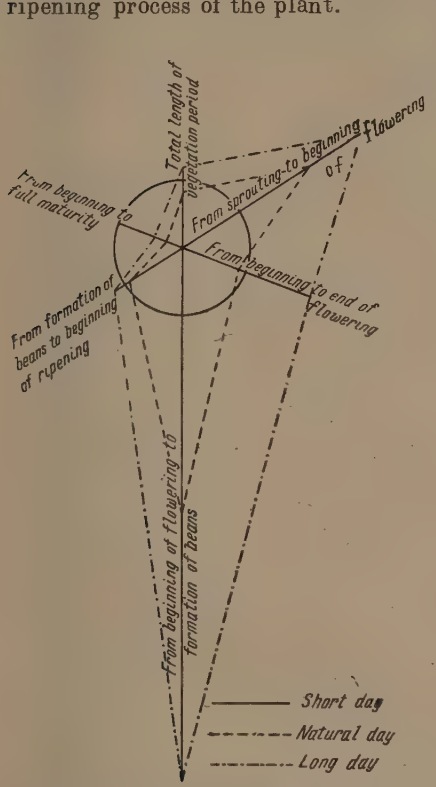

Fig. 1. Variations in the duration of various phases of development in soy-plant Illini induced by changes in the length of day and night

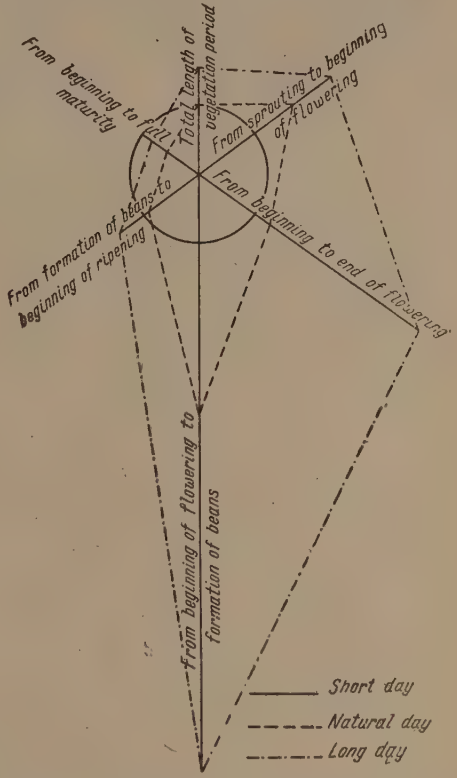

Fig. 2. Variations in the duration of various phases of development in soy-plant Manchzhurskaya № 693 6 induced by changes in the length of day and night

3. Different varieties of soy plant exhibit a different degree of photoperiodic response at different phases of development.

4. The above data would warrant the assumption that there is a dependence of the ripening process in soy plant on the length of day and night. This dependence is that the period of ripening in the soy plant is shortened if the day is lengthened and considerably retarded if the day is shortened. According to other experiments of the writer, the rate of ripening of soy plant and some other plants does not seem to be directly affected by the photoperiodic factor, but depends on the life activity of the leaf, and more particularly, on the ageing process of the green leaf tissue of the plant.

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ZOOLOGY

NEW DATA ON THE DISTRIBUTION OF FISHES IN THE BASIN OF THE IRTYSH

By M. I. MENŠIKOV

(Communicated by S. A. Zernov, Member of the Academy, 13. X. 1937)

The Ichthyological Section of the Zaisan Expedition organized by the Perm State University discovered, on July 29, 1936, specimens of *Diptychus dybowskii* and *Nemachilus strauchi* (Russian names—«osman» and «gubach») in the Kara-su stream, at the village of Akdzhar, Tarbagatai region (about 40 kilometres south of Lake Zaisan, between 47 and 48° N. Lat. and 53 and 54° E. Long. of Pulkovo). The Kara-su is a small stream arising in the foothills of the Eastern Tarbagatai and further down flowing between the spurs of the mountains Manrak and Tologoi, approximately towards the middle of Lake Zaisan. During spring flood-time, the Kara-su reaches the lake, but in summer the stream shallows considerably and then its connection with Lake Zaisan becomes severed.

The osman and the gubach are proper to the zoogeographical subregion of Asiatic mountains. The fact of its occurrence in the basin of the Irtysh (Siberian district of the Arctic Sea province) is therefore interesting from the standpoint of zoogeography. Most probably both these fishes penetrated into the Irtysh basin from the Balkhash province. The presence of these fishes in the Irtysh basin and in any of the other river systems of the Circumpolar subregion in general has not been recorded in the literature [Berg(1)].

Of all the rivers of the Zaisan depression, the Kara-su is the only stream from which these fishes have been reported. They have not been met as yet in Lake Zaisan, in the Chernyi Irtysh and in the lower fishery reaches of the rivers Kenderlyk and Dzharma. We shall now pass to a comparative description of the osman and the gubach caught in the Kara-su.

Diptychus dybowski Kessler, Osman

In the 12 specimens* secured: *D* 11 8, *A* III 5 (in 2 specimens *A* II 5), *P* I 16—17, *V* II 8—9, *l. l*, 89—95, pharyngeal teeth 3.4—4.3. Gill rakers on first gil larches in 4 specimens 9—11. Body naked. Scales only along lateral line and between it and base of pectorals; scaly sheath extending from base of ventrals to the middle of base of anal. Barbels extending in the majority of specimens far beyond posterior border of eye and almost reaching the praeopercle. Ventrals not extending to base of anal. In the dorsal fin, the highest is the second or third branched ray; in the anal, the second and, more seldom, the first; in the pectoral, the second or the third; and in the ventral, the second. Base of ventral fin under the second or third branched rays of dorsal (counting from the posterior end). Length of pectoral always exceeding height of dorsal. Height of anal slightly greater than or same as height of dorsal. Antedorsal distance noticeably greater than the postdorsal, they being equal in one specimen only. Colouring same as in the Balkhash osman.

* 5 of these specimens are now in the collection of the Zoological Institute of the Academy of Sciences of the USSR (№ 26866).

Sexual dimorphism expressed in a number of other characters besides those noted by Berg ([1],[2]). The males, for instance, differ from the females in finer scales along the lateral line, in a longer base of the dorsal and the anal fins. In the males, moreover, the anal is, as a rule, higher than the dorsal, whilst in the females it is equal to or slightly lower than the latter. In addition, the anal fin of the male is distinguished from that of the female by the last (5th) ray being ossified and not branched; the 3rd and 4th branched rays are sometimes but slightly branched and only at their tips being also hard to the touch. Lastly, the origin of the base of the ventral fins in the males is under the second branched ray of the dorsal (counting from the posterior end), while in the females it is under the third. These sexual differences were observed both in the Zaisan osmans and those of the basins of Lake Balkhash and Lake Issyk-kul examined for comparison.

The following table of the range of variations of plastic characters is based on a comparison with the specimens in the Zoological Institute of the Academy of Sciences of the USSR.

A comparison of the plastic characters of the Kara-su osman with those of the osmans from the basins of Lake Balkhash and Lake Issyk-kul shows no essential differences, with the exception of the lobes of the caudal fin, which are shorter in our specimens than in those taken for comparison. The series of the Zoological Institute, however, contains several short-tailed individuals. We must state the same as regards the length of the barbel. The series taken for comparison contained, same as our specimens, both specimens with short barbels, just extending beyond the posterior edge of the eye, and those with long barbels. The difference in the height of the anal fin is due to sexual dimorphism.

Of the 12 specimens examined, 6 were females and 6 were males. The

Characters	Kara-su river, 12 specimens	Zoological Institute. Acad. Sci. USSR, 42 specimens	Chu river [after Driagin ([3])], 10 specimens
Length of body in mm (without C).	73—134	54—181	104—160
In percentages of length of body:			
1. Length of head	23.7—28.3	22.6—28.0	23.4—26.9
2. Greatest depth of body	15.9—19.3	—	17.4—18.8
3. Least depth of body	6.8— 8.8	6.7— 8.2	5.8— 7.5
4. Length of caudal peduncle	15.4—18.2	16.0—20.2	18.1—20.6
5. Antedorsal distance	44.5—51.9	44.2—51.2	46.1—50.0
6. Postdorsal distance	38.3—45.5	39.1—46.4	41.0—44.9
7. Length of base of *D*	10.9—15.0	—	10.6—14.5
8. Height of *D*	15.4—17.1	—	14.6—18.3
9. Length of base of *A*	7.6— 9.7	—	7.7—10.3
10. Height of *A*	16.1—18.7	—	16.3—20.1
11. Length of *P*	17.2—19.7	16.5—22.0	—
12. Length of *V*	13.7—16.5	—	14.6—16.3
13. Distance *P*—*V*	28.0—35.6	26.0—32.8	26.9—31.2
14. Distance *V*—*A*	17.7—20.8	17.0—22.5	18.8—20.9
15. Length of barbels	5.4— 8.1	4.8— 8.9	—
16. Length of upper lobe of *C*	20.6—24.7	20.0—28.6	—
17. Length of lower lobe of *C*	20.6—26.0	20.7—29.2	—
18. Length of median rays of *C*	10.9—13.7	10.7—14.2	—
In percentages of length of head:			
19. Length of snout	27.3—33.3	27.3—32.7	30.8—38.9
20. Postorbital part of head	48.0—55.5	46.0—53.6	46.5—51.7

sexual products, both in the former and in the latter were at the time of their catch at the II and II—III stage of maturity, notwithstanding their insignificant dimensions (73—134 mm). One female of 110 mm contained eggs at the II—III stage. The 73 mm specimen proved a male with well developed milt at the I stage of maturity.

Nemachilus strauchi zaisanicus, subsp. n., Zaisan gubach*

The 27 specimens** secured mesured from 49 to 137 mm in length of body (without *C*). *D* III 7, *A* III 5, *P* I 11—13, *V* II 7—8. Breadth of caudal peduncle greater than or equal to least depth of body. Caudal peduncle longer than or equal to length of head. Least depth of body is contained 3—4 times in length of caudal peduncle. Height of dorsal fin equal to or slightly more than greatest depth of body. Nostrils close together. Greatest depth of body contained 6.8—8.2 times and least depth of body 13.2—17.2 times in length of body. Pectoral fins noticeably longer than ventrals, the latter extending to the anus and more frequently beyond it. The barbels at the angles of the mouth reach to the vertical diameter of eye or extend beyond it. The longest ray of the pectoral fin is the 3rd or the 3rd and 4th together. Caudal fin with noticeable notch. Dorsal and caudal fins have rows of dark spots extending lengthwise the rays. Anal and ventral fins colourless. Pectorals are dark spotted above and colourless below. In the males, the first 5—6 rays of the pectorals (including the unbranched ray) are thickened.

Proportions. In length of body are contained: length of head, 4.2—5.1 times; length of caudal peduncle, 3.9—5.2 times; antedorsal distance, 1.8—1.9 times; postdorsal distance, 2.4—2.7 times; the distance from origin of dorsal fin to base of caudal, 2.0—2.3 times; height of dorsal, 5.7—8. 3; length of base of dorsal, 10.3—13.3; height of anal fin, 6. 9—8. 9; width of forehead, 15. 6—20. 4 times.

From *Nemachilus strauchi* (Kessler) this subspecies differs in the smaller number of branched rays in *D* and in *P*. Whilst in the subspecies the number of rays in *D* is always 7, Berg (1) reports 8 rays for the species, the number of individuals with 7 branched rays being less frequent, namely, 15 out of the 46 specimens examined from the basin of Lake Balkhash. In the subspecies, *P* contains 11—13 branched rays, while in the species it contains 12—14. As regards its plastic character, our subspecies noticeably differs from the species in the greater height of the caudal peduncle, which is on an average 6.66% of the length of body, instead of the 5.37% in the type species, and 28. 38% of the length of the caudal peduncle, instead of the typical 22.85%; in the greater antedorsal distance, which always exceeds half the length of body (being on an average 53. 54% of length of body, instead of the 51.95% in the species); in the correspondingly shorter distance of the origin of the base of *D* from the base of *C*; in a shorter and lower *D* (length of base of *D* being on an average 8.49% of length of body in the subspecies, and 10.48% in the species; and its height being in the subspecies 15.08%, instead of 16.95%, of the length of body); and in a broader forehead. From the Issyk-kul subspecies, *Nemachilus strauchi ulacholica* (Anikin), our subspecies differs in the main, in the smaller depth of body, which is on an average 13.49% of length of body in our subspecies and 14.82% in the Issyk-kul gubach; in the greater height of the caudal peduncle (6.66% of length of body instead of 5.52%) and in its smaller length (22.93 instead of 25.82%); in the greater antedorsal distance (53.54 instead of 50.64% of length of body); in the shorter postdorsal distance (38.10 instead of 41.36% of

* Local «name, golian».

** 18 of them are now in the collection of the Zoological Institute of the Academy of Sciences of the USSR (№ 26863).

length of body); in a lower dorsal fin (15.08% of length of body instead of 16.86%). The subspecies in question was compared with the specimens in the collection of the Zoological Institute of the Academy of Sciences of the USSR, 42 specimens of *Nemachilus strauchi* and 21 specimens of *Nemachilus strauchi ulacholica* being examined. The following table illustrates the differences in systematic characters in the forms compared.

Characters	*N. str. z isanicus* $M_1 \pm m_1$	*N. str. uchi*		*N. str. ulacholica*	
		$M_2 \pm m_2$	$\frac{M_1 - M_2}{\sqrt{m_1^2 + m_2^2}}$	$M_3 \pm m_3$	$\frac{M_1 - M_3}{\sqrt{m_1^2 + m_3^2}}$
1. Length of body in mm (without *C*)	77.52±3.33	86.68±2.38	—	77.40±4.07	—
2. Number of branched rays in *P*	12.22±0.11	13.26±0.08	7.4	11.80±0.14	2.3
In percentages of length of body:					
3. Length of head	21.78±0.18	20.88±0.12	4.3	22.88±0.20	4.1
4. Greatest depth of body	13.49±0.15	—	—	14.82±0.09	10.2
5. Least depth of body	6.66±0.08	5.37±0.07	12.9	5.52±0.03	12.7
6. Length of caudal peduncle	22.93±0.09	23.14±0.21	0.9	25.82±0.31	9.0
7. Antedors. distance	53.54±0.24	51.95±0.15	5.1	50.64±0.42	6.2
8. Postdors. distance	38.10±0.24	38.53±0.21	1.3	41.36±0.39	6.8
9. Distance from origin of *D* to base of *C*	47.20±0.23	48.48±0.15	4.6	—	—
10. Height of *D*	15.08±0.21	16.95±0.13	7.5	16.86±0.20	6.3
11. Length of base of *D*	8.49±0.11	10.48±0.15	11.1	—	—
12. Breadth of forehead	6.00±0.10	5.16±0.07	7.0	—	—
13. Least depth of body in % of length of caudal peduncle	28.38±0.41	22.85±0.33	10.4	21.74±0.26	13.8
14. Breadth of caudal peduncle in % of least depth of body	100.08±1.04	112.42±1.85	5.8	109.05±1.35	5.3

The 10 specimens of *Nemachilus strauchi* described from the Urumchi River by Rendahl (4) (who * simultaneously united the genus *Diplophysa* and the genus *Nemachilus* into one genus under the name of *Nemachilus*, on the basis of investigations of the air-bladder, the position of the intestine, and the appearance of the lips in the various representatives of these genera) differ from our subspecies, in the main, in the same characters as the above-described specimens of *Nemachilus strauchi* from the basin of Lake Balkhash and Lake Issyk-kul. Together with the above-described fishes the following were caught in the Kara-su at the same time: *Phoxinus sedelnikowi* Berg, *Gobio gobio* (L.) and *Cobitis taenia* L.

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* However, these two genera had been first united into one by S. L. Hora [Berg (1)].

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EXPERIMENTELLE ZOOLOGIE

DIE MORPHOGENETISCHE AKTIVITÄT DER VERSCHIEDENEN TEILE DER HYPOPHYSE

X. ZUR FRAGE ÜBER DEN MECHANISMUS DER WIRKUNG DER BASOPHILEN ELEMENTE DES HYPOPHYSEVORDERLAPPENS AUF DAS GEFIEDER DER VÖGEL

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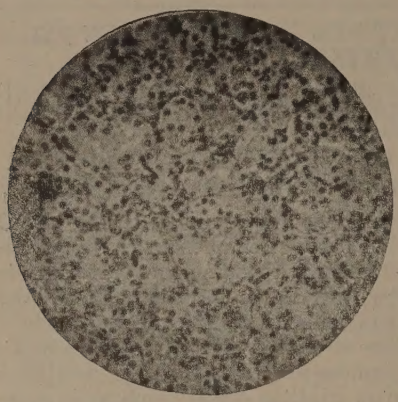
Unsere vorhergehende Untersuchungen (siehe Mitteilung I, II und VIII.) zeigten, dass das Hormon, welches von den basophilen Elementen des Hypophysevorderlappens stammt, stimulierenden Einfluss auf solche formbildende Prozesse ausübt, wie die Metamorphose der Amphibien und die Federbildung bei den Vögeln. In den weiteren Versuchen (siehe Mitteilung III) wurde festgestellt, dass der Einfluss der Hypophyse vermittels der Schilddrüse realisiert wird. Die Stimulierung des Metamorphose-prozesses wird von dem Thyreoideahorn.on bestimmt, welches unter dem Einfluss der Hypophyse in grösserer Menge im Vergleich zu der Norm abgesondert wird. Ähnliche Vorstellung über den Mechanismus der Hypophysewirkung auf die Metamorphose wird auch durch die Angaben von Uhlenhuth und Mitarbeitern bestätigt, welche zeigten, dass die Beschleunigung der Umwandlung unter dem Einfluss der Hypophyse nur bei normalen Tieren erreicht werden kann, während bei den thyreoidektomierten dieser Effekt niemals stattfindet.

In den früher mittgeteilten Versuchen an Vögeln wurde bemerkt, dass die Stimulierung der Mauser und Regeneration der Federn, welche mit der Substanz der «basophilen Zone» hervorgerufen werden, durch die Hyperfunktion der Schilddrüse begleitet wird. Nach der Analogie mit der Metamorphose ist anzunehmen, dass die Stimulierung des morphogenetischen Prozesses auch in diesem Falle vermittels der Schilddrüse verwirklicht wird.

Dieser Schluss verlangt, um volle Überzeugung zu bekommen, noch weitere Beweisführungen, welche für Amphibien in Versuchen an normalen und thyreoidektomierten Tieren erhalten werden können. Die Lösung der Frage an Vögeln kann auf etwas anderem Wege erhalten werden. In unseren früher veröffentlichten Versuchen wurde gezeigt, dass ein langwieriger Reiz der Funktion die Schilddrüse der Tauben in den Zustand voller funktioneller Erschöpfung bringt. Dieses wird durch die künstliche Aktivierung des federbildenden Prozesses erreicht, wozu volle Rupfung einiger nach einander folgenden unreifen Federgenerationen unternommen wird. Als Resultat mehrmaliger Rupfungen kann erreicht werden, dass der grösste Teil des Gefieders sich nicht mehr entwickelt, und die Vögel bis zwei Monate an dem Körper federlos bleiben. Dass das Ausbleiben der Federentwicklung nicht durch Erschöpfung des Federbildendengewebes bestimmt wird sondern durch das Fehlen von Schilddrüsenhormon, wird von mehreren Daten bestätigt. Einerseits, zeigt die histologische Untersuchung der Haut das Vorhandensein von normalformierten Federkeime. Das Fehlen der Schild-

drüsenfunktion kann durch die Resultate der histologischen Untersuchungen, sowie auch durch die biologische Testierung an Kaulquappen bewiesen werden: das Thyreoideagewebe von solchen Vögeln ist nicht fähig, die Metamorphose zu stimulieren (Abbildung). Als ganz überzeugender Beweis der Tatsache, dass das Fehlen des Federwachstums bei mehrmals gerupften Tauben als Resultat der Erschöpfung der Funktion der Schilddrüse folgt, können die Thireoidisierungsversuche dienen, bei welchen immer eine Wiederherstellung des normalen Federkleides beobachtet wurde.

Zur Lösung der oben aufgestellten Frage über den Mechanismus der Wirkung der «basophilen Zone» auf die Federbildung wurden einige solche Tauben mit inaktivierter Schilddrüse verwendet. Die Vögel wurden nach der hier beschriebenen Methode vorbereitet.



Struktur einer funktionellerschöpften Schilddrüse von einer Taube

Zwölf Tage nach der Rupfung (es wurden alle Federn, mit Ausnahme an Hals und Kopf entfernt), zu der Zeit, wo sich die Fahnen an den neuen Federn entwickelten, wurden die jungen unentwickelten Federn wieder ausgerupft. Solche Operation wurde noch zweimal ausgeführt. Nach der dritten, teils schon nach der zweiten Rupfung stellte das Kleingefieder sein Wachstum ein. Der ganze Rumpf, die Beine und die innere Fläche des Flügels blieben nackt. Es entwickelte sich nur noch das Grossgefieder. Schwungfedern und zum Teil die Steuerfedern.

Um zu beweisen, dass die Federkeime, welche ihre Entwicklung einstellten, die Potenz zum Wachstum noch nicht vollständig verloren haben und dass die Reaktion auf das Schilddrüsehormon noch vorhanden ist, wurden einigen Vögeln—intramuskulär—Schilddrüsen von normalen Tauben implantiert. Nach 7—8 Tagen konnten schon junge Federn beobachtet werden, welche sich weiter ganz normal entwickelten. Auf solche Weise wurde gezeigt, dass das federbildende Gewebe, die Fähigkeit auf die Schilddrüse zu reagieren, noch besitzt.

Den anderen Tauben wurden (intraabdominal) Stückchen der «basophilen Zone» des Hypophysevorderlappens zu 200 mg implantiert. Wie die vorhergehenden Versuche zeigten, ist diese Menge von Hypophysengewebe ausreichend, um die Entwicklung des Gefieders bei normalen Vögeln zu stimulieren. Im gegebenen Fall blieben die Vögel im Verlaufe eines Monats ebenso federlos, wie auch vor dem Versuch.

Die Untersuchungen der Schilddrüse zeigten, dass der Zustand der Funktionellen Erschöpfung, in welchem sie sich vor dem Beginn des Versuchs befanden, d. h. vor der Implantierung der Substanz der «basophilen Zone», immer noch vorhanden war. Die «basophile Zone», welche somit nicht im Stande war, die Tätigkeit der Schilddrüse zu aktivieren, ist auch nicht fähig die Entwicklung des Gefieders zu stimulieren.

Hieraus folt, dass das Vorhandensein eines Zwischenglieds, nämlich der funktionierenden Schilddrüse, unbedingte Voraussetzung ist, um das morphogenetische Effekt des Hypophysevorderlappens zu realisieren.

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